RADIATION PROTECTION NOTE 5: THE IONISING RADIATIONS REGULATIONS 2017 & RADIATION DOSE LIMITS

From 1 January 2018, Ionising Radiations Regulations 2017 (IRR17) replaced the Ionising Radiations Regulations 1999 (IRR99). The main aim of the Regulations and the supporting Approved Code of Practice (ACOP) is to establish a framework for ensuring that exposure to ionising radiation arising from work activities, whether from man-made or natural radiation, and from external radiation (eg X-rays) or internal radiation (eg inhalation of a radioactive substance) is kept as low as reasonably practicable (ALARP) and does not exceed dose limits specified for individuals.

THE BASIC SAFETY STANDARDS DIRECTIVE

The 1996 Basic Safety Standards Directive (BSS Directive) reflects the 1990 recommendations of the International Commission on Radiological Protection (ICRP60). Implementation of the BSS Directive in Great Britain is achieved by a mixture of revised regulation (eg IRR17), existing legal provisions, such as the Nuclear Installations Act 1965 (NIA65) and the Environmental Authorisations (Scotland) Regulations 2018 (EPR10 England and Wales), and new provisions, for example proposed regulations on emergency preparedness.

GENERAL PRINCIPLES AND PROCEDURES

1. Justification

   No practice involving the use of ionising radiation shall be adopted unless its introduction produces a positive net benefit.

   The trivial use of ionising radiation should be avoided and each use must be justified taking into account all the adverse effects. Account should be made of the health costs involved in treating malignancies which might result from the stochastic radiation effect and also the economic and other consequences such as the disposal of any radioactive waste produced by the technique in question.

2. Optimisation

   All exposure to radiation shall be kept As Low As Reasonably Practicable taking economic and social factors into account. This is the ALARP principle.

   Radiation exposure must be minimised at all times but good judgement must be exercised. Shielding members of the public from a Cobalt 60 radiotherapy treatment unit will come to a stage when it will have to be decided whether the proposed concrete shielding is thick enough. If the calculated maximum annual dose for a member of the public is already down to one tenth of the natural annual radiation dose, it is justified on economic grounds in not providing additional shielding because the money would be better spent, in the social sense, on providing better health care.

3 Dose Limitation

   The radiation dose limits for each population group shall not be exceeded. If the principles in 1 and 2 are followed, it should seldom be necessary to invoke the dose limits described over. Dose limits do not include exposures received from medical treatment or natural sources.

   In 1983, a study group of the British Royal Society concluded that a continued annual probability of death due to occupational risks of 1 in 1000 might be acceptable and ICRP 60 took note of this in formulating its dose limit. If 20 mSv/year was received throughout a working life, the 1 in 1000 annual risk is not exceeded until retirement age when it is a very small fraction of the annual risk of death from natural causes. This then is the basis for setting the radiation worker dose limit of 20 mSv/year in IRR17. It leads to an average predicted annual risk of death of 1 in 1300 throughout a working lifetime. It is considered that application of the ALARP principle should ensure that very few workers approach the maximum possible radiation dose, so a reasonable degree of safety should result.

IRR17 DOSE LIMITS

To limit stochastic effects the dose limits are

1 Radiation workers >18 years:
The effective dose shall be 20 mSv in any calendar year

2 Members of the public:
The effective dose shall be 1 mSv in any calendar year

3 Trainees aged under 18 years:
The effective dose shall be 6 mSv in any calendar year

To prevent deterministic effects the limits are

1 Radiation worker >18 years:
The limit on equivalent dose for the skin, hands, forearms, feet and ankles shall be 500 mSv/year

2 Radiation worker >18 years:
The limit on equivalent dose for the lens of the eye shall be 20 mSv/year

3 Trainee aged <18 years:
The limit on equivalent dose for the lens of the eye shall be 15 mSv/year

4 Trainee aged < 18 years
The limit on equivalent dose for skin, hands, forearms, feet and ankles shall be 150 mSv / year

5 Women of reproductive capacity
Once a pregnancy has been confirmed and the employer notified, the equivalent dose to the foetus should not exceed 1 mSv during the remainder of the pregnancy.

THE “NATURAL" RADIATION BACKGROUND DOSE RATE

When considering background radiation it is interesting to compare the annual dose limits above with the annual dose received from natural sources.

1. Background Gamma Radiation

All soils and rocks contain several parts per million of uranium and thorium. The daughter radionuclides which arise in the decay chains of these elements emit penetrating gamma radiation which irradiates our bodies. In the Glasgow area, this results in a contribution to our annual radiation dose of 0.3 mSv/year. In granite areas such as Cornwall and the Cairngorms, the figure is 0.6 mSv/year.

2. Cosmic Radiation

The top of the Earth’s atmosphere is continually bombarded with a flux of high-energy protons from outer space and the sun. These protons shatter the oxygen and nitrogen nuclei and produce a flux of mu mesons and neutrons at sea level resulting in a contribution of 0.3 mSv/year to our annual dose. Flying at cruising altitude, we receive an additional dose of 5 μSv /hour which means that aircrew receive a considerable annual radiation dose.

3. The Internal Dose from Potassium 40

All potassium contains 0.012% of the naturally occurring radioisotope potassium 40. This radioisotope has a half-life of 1.26 billion years and has been present since the elements in the solar system were formed. It emits energetic beta and gamma radiation and some of the background gamma radiation is due to the potassium content of soil and rocks and is found in wall plaster.

The human body contains approximately 150 gram of potassium which decays by 4,500 disintegrations per second. This internal body burden, together with small additional doses from trace amounts of uranium, thorium and carbon 14, results in a contribution to our annual dose of 0.2 mSv.

Adding 1, 2 and 3 gives a total annual dose of order 1 mSv which is the same dose allowed to a member of the public.

4. Radon

The decay chain of the trace amounts of uranium in soil gives rise to the evolution of the noble gas radon from the soil and into the air that we breathe.

The radon 222 is an alpha emitting radionuclide with a half-life of 3.8 days and in turn gives rise to short lived daughter nuclei (also alpha emitters) which attach to dust particles in the air. These particles can be trapped in the alveoli in the lung and contribute an addition effective annual dose of 1.2 mSv.